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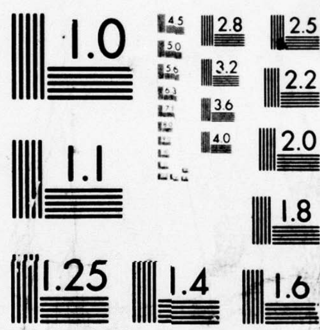
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(10) P.A./Farrell [redacted] B./Quinn

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A PRELIMINARY INVESTIGATION OF NOMAD INSTRUMENTATION BOOM VIBRATION

P. A. Farrell and B. Quinn

Summary

An investigation of the lower order modes of vibration of an instrumentation boom fitted to a Nomad aircraft was carried out and the results are presented. Recommendations for reducing the amplitude of boom vibration experienced at take-off are made.

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16. ABSTRACT:

An investigation of the lower order modes of vibration of an instrumentation boom fitted to a Nomad aircraft was carried out and the results are presented.

Recommendations for reducing the amplitude of boom vibration experienced at take-off are made.

CONTENTS

1. INTRODUCTION

An instrumentation boom has been fitted to the nose of the N22 Nomad used by the Aircraft Research and Development Unit of the Royal Australian Air Force. The boom (fig. 1) undergoes severe vibration when the aircraft rolling speed approaches 33 metres/second (65 knots), but this vibration decays rapidly when the undercarriage is retracted after take-off.

While the vibration does not normally affect the use of this aircraft as this rolling speed is not normally reached before take-off, a series of trials has been planned which will necessitate high rolling speeds. Consequently A.R.L. was requested to make a preliminary examination of the aircraft to determine the natural modes and frequencies of the boom and to make recommendations to reduce the level of vibration.

2. TEST PROCEDURE

The aircraft was supported on three jacks with the undercarriage lowered but clear of the ground. Eight accelerometers were attached to the boom at the locations illustrated in figure 1, and another two accelerometers were attached to the boom supports. The structure was excited by a single electro-magnetic vibrator attached to the boom at the location indicated in figure 1.

The vibrator was driven from a high output-impedance amplifier such that the exciting force was 7 newtons r.m.s. (1.6 lbf r.m.s.). The frequency of the exciting force was varied until the phase difference between the excitation and the response was $\pm 90^\circ$, this indicating a resonance of the structure. At each resonance the amplitudes of vibration as determined from the accelerometer signals gave the natural mode shape.

The vibrator was also moved and attached to the nose wheel but the force available was insufficient to shake the aircraft at this point of high mechanical impedance.

3. TEST RESULTS

Three modes of vibration were measured and these were at frequencies of 15.1 Hz, 20.25 Hz and 39.20 Hz. The first of these modes involves deformation of the fuselage with only slight bending of the probe. The second mode combines the fundamental bending mode of the probe together with significant bending of the fuselage,

tailplane and wings. This elastic mode of an N22 aircraft was previously measured in a ground resonance test at 20.79 Hz (fig. 16 of reference 1 and reproduced here as fig. 2). The last mode is overtone bending of the probe with negligible response of the aircraft structure. Those three modes are illustrated in figure 1.

4. DISCUSSION

Of the modes measured, it is the one at 20.25 Hz that is of concern here. This mode occurs at the frequency indicated by the pilots as troublesome, and it is the mode which involves the greatest deformation of the probe and of the aircraft. Also the unloaded nose-wheel tyre has a diameter of 0.48 metres (1.56 ft.) and so a rotational frequency of 20.25 revolutions/second is reached at a rolling speed of 30.5 metres/second (59.2 knots), provided there is no slippage. Hence, any out-of-balance of the nose-wheel will excite the mode at 20.25 Hz as this rolling speed is reached. After take-off the excitation frequency will slowly decrease as the wheel's spinning slows. It has been observed that retraction of the undercarriage causes the vibration to decrease. There are insufficient data to determine the exact reason for this, but there are a number of possibilities. Firstly, retraction of the nose-wheel moves the exciting force closer to the fuselage node (fig. 2) thus decreasing the resulting vibration amplitude. Secondly, when the undercarriage is down and locked, the vibration is transmitted via the rigid links to the fuselage, but as the nose-wheel is retracted the changing geometry of the links may increase their flexibility thus attenuating the vibration transmitted. This point may be clarified by further testing of the aircraft.

Figure 1 shows that in the mode at 20.25 Hz most deformation occurs in the aft section of the instrumentation probe and in the smallest diameter section of the supporting boom.

5. RECOMMENDATIONS

It is recommended:-

(a) that the nose-wheel be dynamically balanced. This will reduce the force exciting the vibration.

(b) that the boom be stiffened where the largest modal deformations occur. This is at the aft end of the instrumentation probe and the smallest diameter section of the supporting boom.

This stiffening will give the dual advantage of decreasing the amplitude of response to a given force input and also raising the resonant frequency of the boom above that of the elastic fuselage mode shown in figure 2. This stiffening can be achieved by the application of carbon-fibre reinforced plastics to the outside of the boom and probe at the area to be stiffened. This method of stiffening is suggested as it involves only minimal interruption to the aircraft's flight programme. If however, this stiffening proves to be insufficient, then a redesign of the boom may be necessary.

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1.	Long, G. and Cox, Petra M.	Resonance Test on Nomad Production Version Tech. Memo. A.R.L./Struc. 230, 1975.

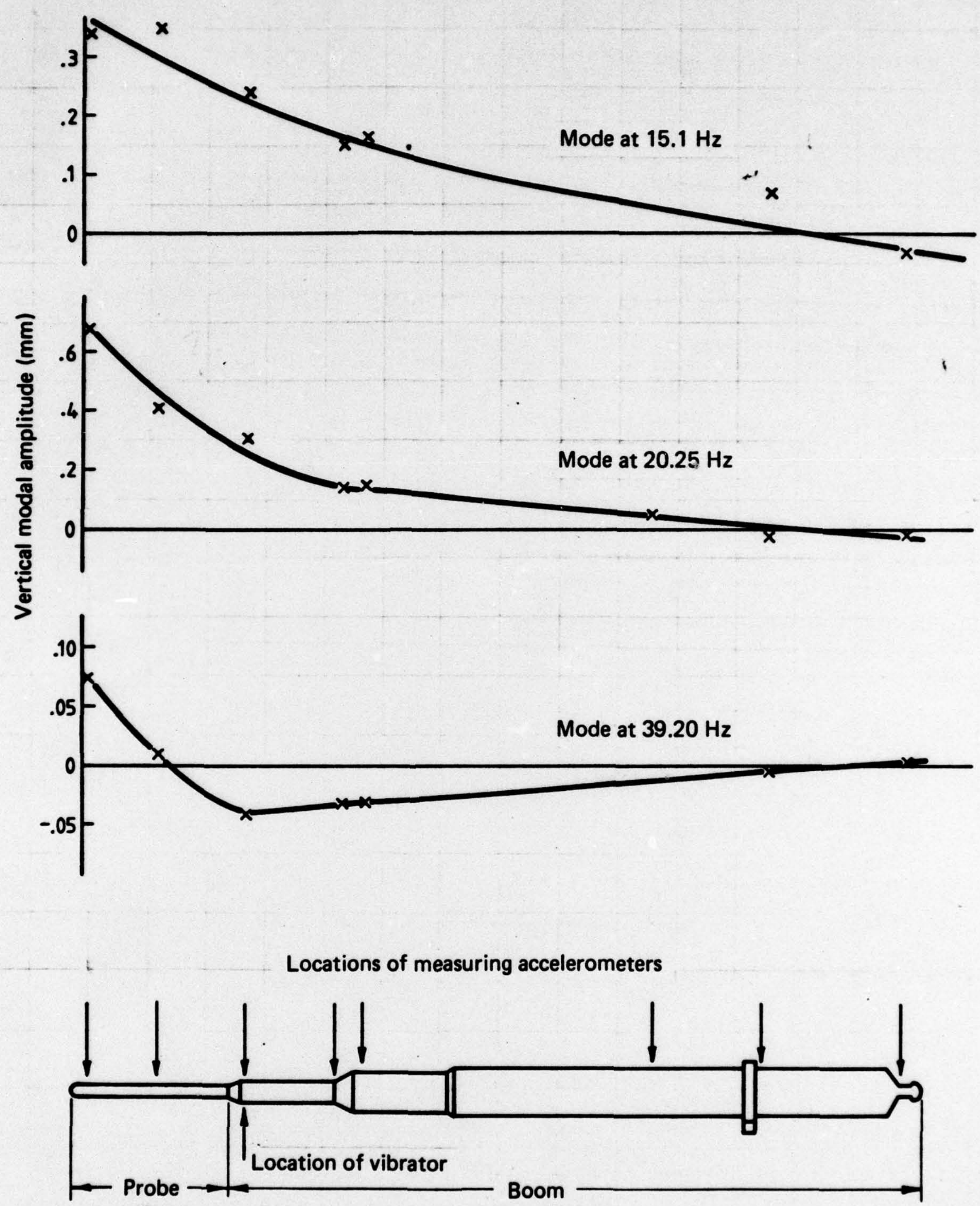

FIG. 1 DETAILS OF MEASURED MODES

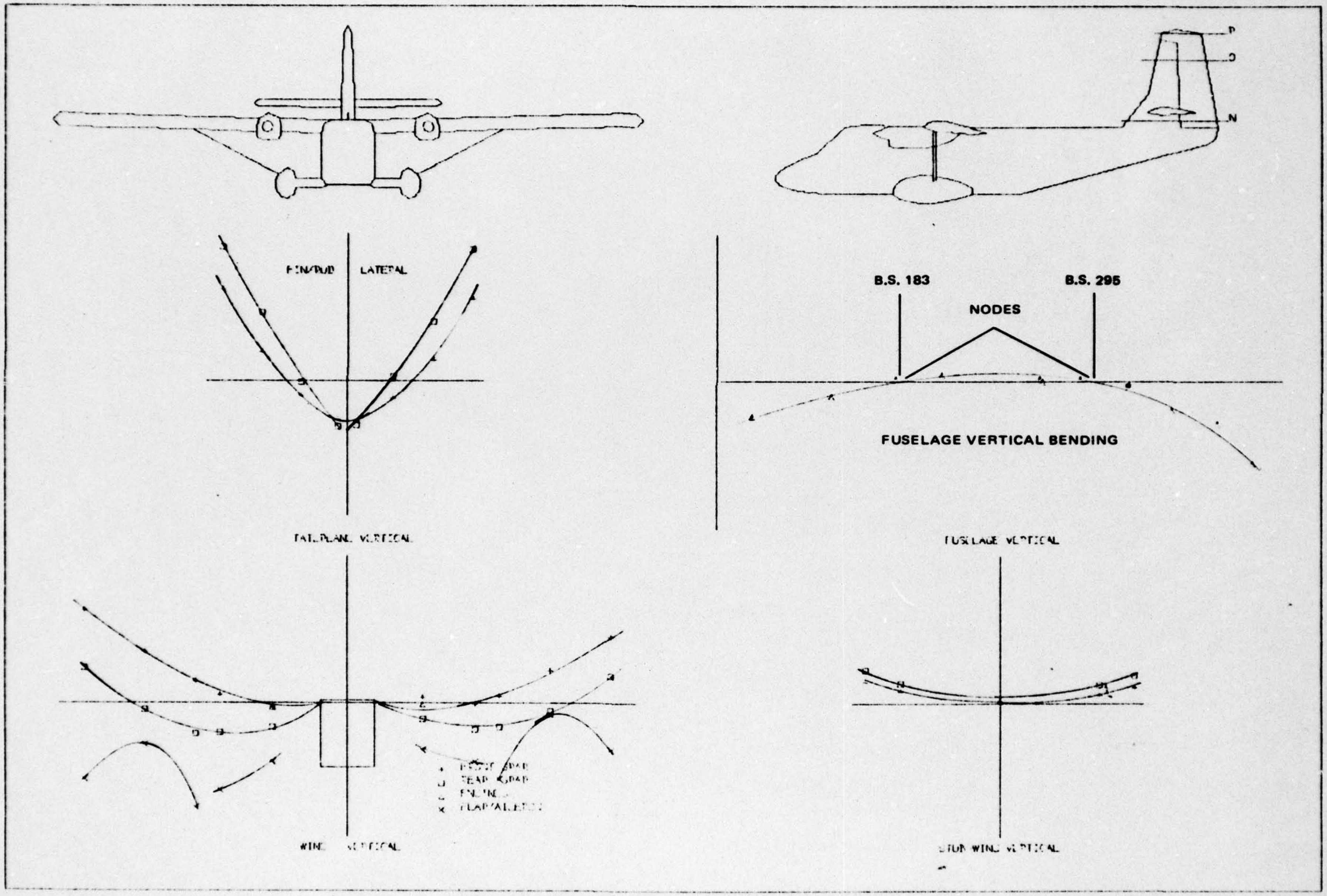

FIG. 2 MODE MEASURED IN PRIOR RESONANCE TEST

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